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## Science Work in the Speyer School.[1]

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The war is the most vital factor in the world today. America is the most vital factor in the war. Education is the most vital permanent factor in America. Science, considered in the large, can and must become the most vital factor in Education. We, to whom has been entrusted this dominant note of modern life, are now confronted with the golden opportunity for change which comes with every cataclysm in life.

These rather bold statements describe to my mind the nature and direction of educational thought and activity of the last two years. And in the almost feverish desire which exists to do and to do quickly, no movement more than the junior high school movement has been the outlet for educational endeavor. The junior high school seems to have become the vehicle for "Democracy in Education." It presents a field from which tradition is gone; a field where ideas can be put into practice with a minimum of disturbance to existing systems; and it gives us the golden opportunity for change. The Speyer School represents a piece of concrete experimentation with the junior high school idea, and has drawn inspiration and was meant to function in this educational background.

About two years ago the New York City Board of Education and Teachers College decided to co-operate in an experiment. The city supplied 250 boys chosen from as many districts as was possible, who were about to enter the seventh grade. Psychological and other tests as well as teachers' tests and opinions proved the group to be an entirely average and representative group of New York City boys. The attempt was to be made to fit these boys for second year high school in the last two years of the elementary grade. The administration of the school was in the hands of the

1 Paper read at the Science Round Table, Teachers College Alumni Conferences of 1918

city; while Teachers College supplied the teachers of special subjects with Prof. Briggs as educational adviser for the school. Among the many important and interesting features of the experiment, I wish but to mention the unique provision for Individual Differences, which affected immensely the work in every subject. The boys of the school were divided into ten nearly equal groups; group 1 being the best, group 2, the next best, and so on down to group ten which was the poorest. The basis for classification, was again, psychological tests and educational scales and standards coupled with teachers' opinions. As better knowledge of the individual was obtained, a continual readjustment of groups was kept up. The result was that after two years our group one *was* group one in every subject and in every school activity—even to that of raising Red Cross funds. The educational possiblities in dealing with classes of such uniform ability and attainment are too evident to need further discussion.

The two-year period for experimentation is now over. We have sent our first batch of boys into the second year of the Senior High Schools of the city and are awaiting results. In the meantime, the tide of events in New York has suddenly swept the 6-3-3 plan or Junior High School movement into prominence. The president of the New York Board of Education, proposes a reorganization of the entire city system on the Junior High School basis; and Prof. Briggs, fresh from his studies and experiments in the Speyer School, has been called upon to advise in the reconstruction.

Science at the Speyer School is given twice a week for an hour each time. Our science room is a former cooking room which came to us entirely unmodified and our equipment throughout the two years was practically nil—owing to the slow moving wheels of our city system. We were supplied with six of the recent texts in general science and with a permit to loan apparatus from the Teachers College laboratory, when that apparatus was not there in use. These were rather trying circumstances; especially since it was the idea from the start to teach by the project method, a method so new to class-room procedure, as to offer in itself sufficient difficulties.

The project method in theory, has been discussed, evaluated, and urged by Prof. Dewey, Prof. Kilpatrick, and others, while in science teaching, Prof. Woodhull has done most in applying the idea. In the following outline, I have tried to summarize the

situation in project teaching as I see it. The ideas are fine, definite and clear. The carrying of these ideas into practice is still to be done.

## THE PROJECT METHOD.

A. Historical Sketch

(1) The famous pioneers of science such as Faraday, Davy, Huxley, and Tyndall advocate in their work, method and teachings an attitude and study of science which is identical with the project method.

(2) With the report of the Committee of Ten standardizing one year of science for college entrance, science teaching became a formalized subject removed from actual life problems.

(3) The project movement is virtually a reaction toward the popularization of science advocated by Tyndall, Huxley and the rest—with modern philosophy and psychology of education as a back-ground.

B. The movement.

(1) It is closely allied with the spirit of democracy in education.

- (a) It aims to meet the individual and social needs of the citizen.
- (b) It opposes the science teaching of today in that the latter selects the few and does not develop the many, aiming at "Culture" instead of at citizenship.

(2) It is closely allied with the teachings of modern psychology.

- (a) It aims at "learning from experience".
- (b) It aims to employ content and method that have a high transfer value.
- (c) It upholds the psychological rather than the logical.

(3) In response to the above point of view the movement;

- (a) Disregards the traditional lines between the sciences.
- (b) Concerns itself with interpreting the environment in its broadest sense.
- (c) Glorifies the application, the invention, etc.
- (d) Attempts to give a broad attitude toward life by instilling a love for nature.
- (e) Considers specialized "research" science as the upper limit of a line of growth of which line in itself forms the lower limit.

C. A project is charactarized by:

(1) A desire to understand the meaning and use of some fact, phenomena or experience.

(2) A conviction that it is worth-while and possible to secure an understanding of the thing in question.

(3) The gathering from experience, books and experiments of the needed information and the application of this information to answer the question in hand.

D. Dewey's tests for projects.

(1) Is it real, vital—or is it formal?

(2) Is there anything but a problem? Does it arouse experimentation outside of school?

(3) Does it come from within, or is it imposed from without.

(4) Does the student have the necessary background for solving the problem?

(5) Is its difficulty proportionate to the ability of the student.

E. A project vs. a topic.

(1) A project originates in some question and not in such a logical sequence of ideas as may be found in codified subject matter.

(2) A project involves active and motivated participation of the pupil. A topic lends itself to formal treatment in which the teacher does all the thinking.

(3) Projects furnish a basis for the selection of facts according to value or significance. Topics do not.

(4) A project seldom ends in a complete final or absolutely finished conclusion.

TWO CONFLICTING VIEWS.

F. The various laws and phenomena of nature worked out as projects should not be worked out as a course of study.

(1) The projects would become topics.

(2) It is impossible to organize the problems of life.

(3) Projects must vary with every community.

(4) Our good "sample projects" are good only where they originate.

(5) Organization leads to standardization.

(a) Standardization ties the good teacher's hands.

(b) It does not aid the poor one materially.

(6) A great quantity of sample projects is the felt need of all

teachers in lieu of an organized course of study.

G. Projects should be organized into a course of study.

(1) Random projects lack unity.

(2) Without organization we lose the disciplinary value of project study.

(3) Without organization we cannot instill the broader attitude toward life which science can give.

(4) Without an organized course of study class room procedure tends towards inefficiency.

(5) The doctrine that "problems should originate from within" is limited to the extent that there already exists a scientific environment around the child which must be interpreted.

(6) These necessary elements (minimum essentials) problematized and then organized can constitute the course of study.

(7) A course of study does not necessarily mean a slavish adherance to it.

For a year the science work at the Speyer School was a series of projects—group projects, with the teacher taking the leading part. Each project was entirely unrelated to the next one, and in each case the class as a whole dealt with the same problem. In actual procedure the "group project" differed very little from the usual lecture or class demonstration. The problem may have been suggested by the pupils; but the teacher gathered the material, the teacher organized it, the teacher prepared the apparatus, the teacher performed the experiments—in fact the teacher did the thinking. Whatever, justification in theory that we had for our freedom in choice of material, was not at all sufficient after a years work with the "group project", in making us satisfied with our results. To have a whole group on the same project restricts the project. Conditions are unnatural. The pupils are too numerous. They must be kept quiet and restrained, or the discipline will be such as to neutralize all your efforts. There isn't anything which more than a project creates and fosters a restless spirit in the class. Everybody is up on his toes and wanting to relate personal experiences, give advice and ask questions; and although in a sense no one can call this disorder, it renders the teacher inefficient, unless he is willing to suppress some of the enthusiasm and ignore some of the questions.

To avoid these draw-backs and to carry out more fully the intent of the project science work, the second year, was developed

along two lines which I shall now try to set forth in detail. First, is what may be termed the "individual project" as distinguished from the group project; and second is the utilization of club work and other extra-curricular activities in teaching science.

First as to the individual project—The primary aim is to get every boy in the class working on a problem which will be entirely his own. In choosing the problem we struck a sort of compromise between the individual interests and desires (this received of course the most consideration) and certain general ideas of the teacher concerning the purpose of the course and its organization. With the latter I shall deal more fully later on. Each boy being provided with a subject in which he is interested, which is worth-while, and which is suited to his ability, work commences. In his work he is guided as follows: First it is announced to the class that on Nov. 12th, three or four weeks hence, George Richter is to have a period in which he is to lecture to the rest of the class on the submarine. And that George wants now to find out what the class would like to know most about the submarine. From the horde of volunteers, including George himself, we finally crystallize the following as an outline:

1. Who invented the submarine? When? How was it developed?
2. How can it submerge and emerge?
3. How is it driven?
4. How does the crew breath?
5. How does the crew live?
6. How does it see and steer?
7. How does it attack and defend?
8. What special dangers does it run?
9. To what uses can submarines be put after the war?

With that much to start on, George gets busy and for three weeks or more, he gathers material from books, magazines, newspapers and pamphlets. About once a week he holds a five or ten minute conference with the teacher who helps him across the hard parts. He writes to firms for interesting pamphlets, pictures and diagrams, he writes to the public library for their set of lantern slides and carries out numerous little experiments at home and at school, dealing with the principle of the submarine. These experiments are suggested by himself, the teacher, or the books, magazines, etc. which he reads. A few days before the date set, he posts a list of

about fifteen questions on the class bulletin board, which questions cover all of importance that he is going to say about his subject. This list which the teacher of course inspects, the whole class copies into their note books. When the day for the lecture arrives, each boy has the set of questions before him and is expected to answer the questions after listening to the speaker. The latter stands at the head of the class—the master of ceremonies. He performs experiments, shows charts, uses the black board, operates the projection lantern, asks questions and grants the privilege of speaking to the other members of the class. The most mediocre and nervous of boys, when full of information on his subject, and possessing the feeling that he is considered by all the authority will handle himself and the class in a most effective manner. The teacher sits in the rear, and is usually lost in the back ground. He is there to guide and direct when necessary, and to curb every now and then the rapid fire of questions at the lecturer by the class. The participation is always universal. After almost a year's trial of this form of "socialized recitation" I look back on some of the most pleasant hours of my life. If for no other reason, I recommend it to teachers as a relief from the nervous strain of the class-room.

With group one of the school, the best group, I have obtained results which I can charactarize by no other term than remarkable and even in the poorest groups, I have obtained advantages that made the scheme worth-while. In the poorer groups, I found it very helpful to keep constantly before the boys a series of questions which I called instructions for lecturers. By the end of the term these instructions had become a sort of constitution for class room procedure. They read as follows:

INSTRUCTIONS FOR LECTURES

In preparing for your lecture, ask yourself or do the following:—

1. What is my subject?
2. What are the 3, 4, 5, or 6 most important facts I wish to bring to the attention of the class?
3. What is the best order in which to present them?
4. Under each of these big topics, what are the details that belong to them, and which do you plan to present?
5. Omit those which are unimportant.
6. Don't repeat yourself. It wastes time.
7. Are there any facts or ideas that you can explain better by means of a diagram?

8. Are there any facts or ideas that you can explain better by means of a picture or pamphlet?
9. Can you profitably use lantern slides? Can you get them?
10. Do you need specimens? Can you get them?
11. Are there any facts or ideas that you can explain better by means of an experiment?
12. If so, how long will the experiment take?
13. Is it worth the time? Is it worth the effort? It it possible to get the apparatus?
14. Can you work it before the class?

Remember that:

1. In one hour you cannot tell all you know about your subject.
2. The boys in your class have not studied the subject yet.
3. The boys in your class must be made ready to understand
4. Everything you say must have some bearing on what you what you say.
   are trying to explain.
5. If you have any conclusions, you must drive them home by making clear to everybody what they are. If you haven't any conclusions you must find them.
6. You must watch the clock as you speak.
7. Your classmates have no right to side-track you on other subjects.
8. Your classmates have a right to ask about things which are "in order."
9. Your questions must be clear and definite.
10. If you don't finish on time it is your own fault.

With few exceptions, the class hours were taken up with these lectures, each boy being given a date. The exceptional periods were devoted to review, summary and examination. At the end of one term of such work, each of our two hundred and fifty boys, under the care of two teachers, who spent on the average fifteen hours a week each at the school, has had at least one turn to lecture, has worked on at least two projects, and has answered correctly in his note book twenty-four sets of questions.

So much for the "individual projects" and the "socialized recitation." Both have disadvantages, and in both we run certain dangers; but neither the disadvantages nor the dangers are of such a nature, as to be without remedy, nor as to neutralize the good

which is involved. But by itself the problem of method, even when most satisfactorily solved, does not remove all the obstacles in teaching science. The question of content, of subject matter, of course of study, remains. Where are we to draw our projects from? To put it entirely up to the particular boy's interest, means very often to cater to a mere whim or fancy. There is no guarantee that the interest is a real one. Frank for example wants tremendously to lecture on acetylene gas because while going to school this morning he found a pamphlet advertising it. And Harry wants to lecture on the planets because his brother has a book on astronomy. What is more, like with any other human group, we usually find those that flit from one thing to another, those who specialize intensively, those who jump to the speculative questions, such as evolution, the ether and molecular theory, and of course those who don't seem to have any capacity for interest in science. It became essential, therefore, for the teacher to guide and control the content of work.

Prof. Briggs has set those two theses for the entire school and for all subjects. "It is our business in the school" he says, "First, to teach pupils to do those things better which they will do anyhow. And second, to open up for the pupil certain higher activities, make these activities possible and to some extent desired." For science, that means three things;

1. We must find out what is the modern scientific environment in which our boy is soon to find himself. And we must interpret this environment.
2. We must find out what elements of the scientific spirit and attitude function in life. And we must interpret that.
3. We must explore the fields of science and give ample nourishment to whatever embryo Newton's, Faraday's and Edison's that we may have.

I confess that stating our aims in this fashion does not answer the question; yet it does indicate a possible solution. From the very nature of the task this solution will vary widely. It will vary with locality, with the individual, with the occupation, with the age, and with several other factors. At the Speyer School it took the following form.

The general organization of the school issued a Speyer Creed which every Speyer boy lived up to and almost worshipped. Ac-

cording to that creed, a Speyer boy was trustworthy, a Speyer boy was loyal, a Speyer boy was helpful, a Speyer boy was respectful, honest, etc. etc. I insisted, and won my point, that a Speyer boy is also intelligent, and that a Speyer boy is also handy. And so two new laws were added to the Speyer Creed which represented the science in our school life. I shall take the time to read these two laws, because it served as my course of study—the source of the projects for the boys.

### TWO ADDITIONS TO THE SPEYER CREED.

11. A Speyer boy is intelligent.

(a) He is an intelligent reader of newspapers for he knows a good deal about:

1. Aeroplanes and Zeppelins.
2. Submarine.
3. Guns and explosives.
4. Wireless.
5. Liquid fire.
6. Periscope.
7. Camouflage.
8. British Tanks.
9. Life Preservers.
10. Irrigation.
11. Radium.
12. X-Ray.
13. Perpetual motion.
14. Gyroscope.
15. Earthquakes.
16. Volcanoes.
17. Eclipses.
18. Coal mines
19. Weather prediction
20. Telegraph.

(b) He is an intelligent member of his family for at home he knows a good deal about:

1. The clothing he wears.
2. The food he eats.
3. Soaps, pastes and powders.
4. The piano and victrola.
5. Electric light and gas mantle.
6. Oil, gas, and electric stoves.
7. Radiators and ventilators.
8. Vacuum Cleaner.
9. Thermos Bottles and Fireless Cooker.
10. Bells and push buttons.
11. How to read the gas and watt meters.
12. Where to hang mirrors.
13. Seltzer siphons.
14. Matches and candles.
15. Clocks and watches.
16. Hot and cold water supply.
17. Antiseptics.
18. Food preservatives.

(c) He is intelligent when walking or playing on the street, for he knows a good deal about:

1. Fire Engines.
2. Automobiles.
3. Street cars and trains.
4. Telephones.
5. Elevators.
6. Electric signs.
7. Arc and Nitrogen Lamps.
8. Moving pictures.
9. Steam roller.
10. Fire Hydrants.
11. Sewers.
12. Cranes and Derricks.

(d) He is an intelligent member of his school for he knows a good deal about:

1. The pulleys in the gym.
2. The basket ball pump.
3. Tuning fork in the music room.
4. Thermostats, thermometers and ventilating registers in each room.
5. The furnace and boiler in the engine room.
6. The fire extinguisher in the hall.
7. The alarm bell system in the building.
8. Projection lantern in assembly.
9. The grindstone and motor in the shop.
10. Apparatus in the science room.

(e) He is intelligent when going on his vacation, for he knows a good deal about:

1. Field and forest.
2. Bird and Beast.
3. Flower and insect
4. Sun and moon.
5. Stars and planets.
6. The milky way.
7. The rainbow.
8. The use of the camera.
9. Farming and woodcraft.
10. Waterfalls and waterpower.
11. The cream-separator.
12. The tides.

12. A Speyer boy is handy.

He is quick of eye and nimble of hand. Here are some of the things which a Speyer boy can do:—

(1) Repair his bicycle and skates.
(2) Regulate the clock in the house.
(3) Fix the radiator so that it does not hiss steam.
(4) Tighten a gas valve so that it does not leak gas.
(5) Tighten a water faucet so that it does not leak water.
(6) Wire up or repair a push button, bell or light switch.
(7) Adjust a gas mantle so that it can last long and give good light.
(8) Pump up a basketball in the gymnasium.
(9) Wire up a desk lamp.
(10) Repair a gas stove.
(11) Regulate and take care of a player piano or Victrola.
(12) Replace a burnt out electric socket.
(13) Repair a small electric motor.
(14) Run the assembly lantern slide machine.
(15) Make a periscope.
(16) Make a pin-hole camera.
(17) Calculate the gas, water and electricity bills by consulting the various meters.
(18) Make a temporary and permanent magnet.
(19) Connect batteries and storage batteries.
(20) Repair a lock.
(21) Build a toy aeroplane.
(22) Run an automobile.

This is a rather formidable array of subject matter—but if the idea be kept in mind that in the junior high school we should survey each project in a general fashion, hitting the high spots so to speak, such a course of study can be easily completed in the

seventh and eighth grades, giving science two hours a week. Of course, depending upon the locality and particular needs, the "course" if we may call it that, will be stressed differently, amplified, changed or reduced. I am thoroughly convinced though, that after all the adjustments to various conditions have been made, there will remain an irreducable minimum common to all communities of modern life. Experiment only can definitely determine these "minimum essentials" in science.

I stated before that the science work at the Speyer School developed along another line, quite apart from class work and a line which I consider juite as significant. What I have reference to is the Speyer Science Club.

It seems to me that with the changing conception of the school and school house, with the many and varied socializing agencies within the school unit, that accompany this conception, the school, as never before, becomes a living force in the life of the pupil. The Speyer School became that kind of a potent influence. It was decidedly up to each subject to contribute to this social force or be snowed under. It was up to us in science to introduce a scientific culture into the little Speyer community after school hours, or be considered in a class with the other school drudgeries. And so there arose this Club with its constitution, set of officers and nearly seventy-five members. To be a *grade A science club member* meant to be one of a group of twenty picked boys who received A in science every month and who devoted all their extra curricular time to science. These twenty, under the teacher's guidance, became the masters of the school environment. They were known and recognized all over the school by their green and white S S C arm bands which they religiously wore. They were called upon by teachers to regulate radiators, clocks, ventilators, and ventilation. They fixed the water faucets, electric switches and sockets. They were on good terms with the janitor and had access to the boiler room. They operated the assembly projection lantern and the school Victrola and player piano. They actually repaired the school fire alarm bell system when the janitor gave it up as a bad job. They installed a bell system in the school which announced the ends of periods, and also a complete home-made telephone sytsem from office to gym, to science room. To be a *grade B science club member* meant to be one of a group of about fifty boys, who either because of their inability to get A in science each month, or

because of other school activities, could not completely devote themselves to such work. These boys attended meetings, were given the privilege of listening to prominent outside lecturers who visited the club, were invited to attend our trips to large industrial plants, and were expected to make some contribution to the work of the club.

The club held scientific initiation ceremonies for new members. It assigned tasks to applicants such as reconstructing a small electric motor, given its seventy-five odd parts all jumbled up in an envelop. It took over some of the school assemblies and gave an exhibition of its work together with several scientific tableaux. It ran a Scientific Grab Bag and raised a sum of money for which to purchase the Book of Knowledge. It had its meetings announced by means of large electric signs. And it played a prominent role in the columns of the school paper. One particular group of these boys, altruistically inclined, decided to call themselves the Scientific Helpers with the idea of aiding some of the boys in the school who found special difficulty with their lectures for class work. They made a list of all possible projects and laboriously went through our library of more than two hundred books, as well as numerous periodicals and listed the page, etc. where information could be found on each project—adding hints and suggestions. These they filed away in an index cabinet. They are still at work and I hope to have a rather valuable organization of material as a result. It is needless to discuss the value to these boys, of such work. I might also add that our library was entirely in the care of the boys themselves, there being a librarian present each afternoon of the week to distribute books and give aid. The teacher's part in all this was very difficult and exacting only in the beginning. Once organized, the boys almost forced the teacher to retire.

Originally I organized this group to combat the apathy which existed towards the science class and things scientific in general. It seemed entirely contrary to the supposed interests of boys that there should be a flourishing Latin Club in the school, among other things, and no interest in science. As the science club developed and changed apathy to enthusiasm, I found myself dealing with quite a different problem, namely: the problem of laboratory work in general science. I believe, that as yet no one has proposed laboratory work in this field for we have been quite satisfied

to reserve the laboratory for the more formal study of the various sciences; partly because general science has been so uncertain, and partly, I suppose, because of the unwillingness to double an already difficult problem. But as the movement increases in force, that phase of the work is beginning to demand more serious consideration. I feel that in the work of the Speyer Science Club a few suggestions may be found. For example, at its annual exhibition, the club exhibited more than sixty pieces of apparatus, scientific toys, etc., which they themselves made at home, in school, or in the shop. The results were rather crude, but interesting and what is of greatest importance, workable. I cannot do better than to submit a list of the more important of these bits of apparatus.

There was first a telephone receiver and transmitter set made from an iron rod, a spool and a tin can. It worked admirably. There was also a box camera, made from a card-board box and a cheap convex lens. We took a fairly good picture of the class with it, the boys doing the printing and developing in our closet fixed up as a dark room. Then there was a fire-extinguisher made from two bottles and a piece of rubber tubing; and lantern slides that made announcements to the school in the assembly; and some very tiny motors made from an iron nail, some wire and a horse-shoe magnet.

On a small scale, we had a water wheel that drove a miniature power plant with faucet water pressure, a periscope, several submarines, a telescope, a steam-engine model, a storage battery, a wet cell, a dry cell, an electric bell, an ingenious reversing switch, a thermo-meter, a pump, an induction coil, a fireless cooker, an ammeter and voltmeter calibrated to read fairly accurately, magnetic compasses, telegraph sounders, a small projection lantern, a reflectoscope, an immersion heater, a variable rheostat, an aeroplane model, a transformer, a spectroscope, and an electric lamp.

In connection with the above several of the boys went through the entire Gilbert and Zeno Chemical Outfits. For those who are unfamiliar with these "Outfits" I shall submit parts of the Table of Contents of one of these Outfits.

PARTS FROM THE TABLE OF CONTENTS OF GILBERT'S CHEMICAL OUTFIT

How to coat an object with nickel or copper.
How to make a duplicate of your medal.
How to etch electrically on copper.

How to etch upon steel.
How to petrify the baby's shoe.
The lemon electric cell.
Make your plaster cast into metal.
Plating by simple immersion.
Beauutifully colored precipitates with phenolthalein.
Testing for metals by the flame colors.
How to make ammonia.
How to fireproof cloth and wood.
Making chemical soap bubbles.
Inserting an egg into a bottle by softening the shell.
How to start a fire chemically.
Making frosted glass.
How rock candy is made.
Make your own ink.
Disappearing ink and why it disappears.
Making illuminating gas.
How to make an acid from wood.
How charcoal is made.
How diamonds are made.
How to make your own soap.
Manufacture of soap powder and shaving cream.
How glass is made.
etc. etc. etc.
A magic program and magic tricks.

In all of the above our material was either supplied by the boys themselves, was reclaimed from the Teachers College Junk Room or it was bought with the ten dollars which the General Organization of the school gave us. I feel that I can very safely say, that given a laboratory manual, written along the lines of the Gilbert Chemical outfit (minus the cheap advertising features and perhaps the appeal to the sensational) and given also about $75. to $100.—and a type of laboratory work for general science can be introduced which will enrichen and make possible the highest type of project teaching. That and the use of the school building as a laboratory are two ideas which our work with the science Club has proven to be highly practicable.

One further fact did our work of the past year crystallize into a need which I feel must soon be met. We must have a suitable text. I realize that I am treading on dangerous ground. I realize that the formalizing influence of a text may destroy whatever good has been accomplished by the project idea. But I cannot help feel that a text can be written that shall guide and suggest and not hinder—that shall provide suitable sources and definite work-

able material that experience has proven to be of value. I will venture a series of requirements for a text, that would be of immense value to me. Let other teachers do the same. Is there not the possibility that in this manner we may develop such a book? In my text book I want to find:

(1) The "minimum essentials" of science worked out on some such plan as I have previously discussed.

(2) With each "essential" I should like to find:

(a) A biographical sketch of the inventor.

(b) A brief history of the developement.

(c) An explanation that will lead to an understanding and appreciation.

(d) Clear and simple diagrams and pictures.

(3) An interesting manner (with apparatus etc.) of presenting each particular essential to a class.

(4) A list of simple constructional exercises and experiments with instructions as to how pupils can perform them, including place of purchase and price.

(5) A rather extensive bibliography of material that boys can read and appreciate. This ought to include fiction.

(6) A set of leading questions with each "essential".

(7) A "cultural transmission" which will use each of the "essentials" as a means of leading those who are capable of it onward to "research" science, or high appreciative and theoretical science.

And together with the text should be the laboratory manual of which I spoke before—that collection of material to be found in Morgan's Boy Electrician or Woodhull's Work and Play series or the Chemical Outfit or the various other construction manuals for boys.

In conclusion let me summarize what I have been at such length in saying, for fear that I have perhaps been rather disorganized in my presentation.

(1) The war is demanding a change.

(2) The Junior High School is our opportunity for change.

(3) The PROJECT METHOD is the most significant change in educational method.

(4) The project idea finds fertile soil in science teaching.

(5) The Group Project does not solve the problem.

(6) The Individual Project combined with a socialized form

of recitation, offers certain very valuable advantages, and is more in keeping with the project spirit.

(7) A Course of Study of Minimum Essentials is a possibility that is not incompatible with the project idea. (Speyer Creed.)

(8) It is absolutely essential that we utilize the social nature of the boy and make each and every subject a part of the real life of the school. (Speyer Club)

(9) And finally there is a demand for a different type of laboratory work and a different kind of text book—which will guide without restricting and help materially in the process of increasing our crop of scientific specialists—while at the same time we produce a citizenship of men and women really appreciative and intelligent in judging the affairs of life.

## What Eighty Teachers Think as to the Aims and Subject Matter of General Science

C. M. HOWE, HUGHES HIGH SCHOOL, CINCINNATI, O.

General science has now attained some years of age, and a surprising degree of recognition in our high schools. Her friends and champions are many, and yet, in some quarters this new member of the secondary science family is treated with suspicion and contempt. In some schools, the other members of the teaching staff, while admitting the need and possible value of such a course, have little but honest scorn for the wondrous conglomeration presented under that name in their school. A fad they term it—general enough in truth, but unworthy the name of science.

Allowing for traditional conservatism or inertia, and for jealous rivalry, it has seemed to some of us who have advanced from this attitude to one of appreciation and optimism, that no small part of this hostile skepticism, this questionable repute, is due to the nondescript and chaotic status of this subject. What is general science, anyway, asks the caviling critic, and who can answer? What can be expected in later special science courses from those who have had a year of general science? What weight should a credit in general science carry in case of transfer to another school? Who knows—a careful survey of the texts available

reveals an almost grotesque variation as to selection of material, relative emphasis, and omissions. And as if this were not enough, almost every young teacher with a year or so of experience essays the development of a brand new, original, and wonderful course—a notebook or text. A sign of vigor you say—but perhaps also one of peril.

For general science is, in a way, on trial. Her future is at stake. Is it to be a course of extremes and faddism, of pretence, shallowness, and superficiality, protected by excess of freedom? The writer believes that the time is ripe for the mass of sane but liberal science teachers who are engaged in this work to insist on, and cooperate in, an evolution of some definite standards to guide, in the planning and judging of general science courses. This need not mean iron clad syllabi, with a checking of individuality and adaptation, but it should mean first, an honest and serious attempt to answer two questions on which depend the reputation and the future of this subject.

The two questions are simple. Why are we teaching general science —why is such a course needed—a clear statement of dominant aims. And then—what are we teaching—what should we teach—a definition of content, and in a tentative way, of minimum essentials. On the first question, that of aims, many opinions have been voiced, in the prefaces to texts and in periodicals, with a hopeful tendency toward agreement. But on the question of content, agreement would seem almost hopeless. An attempt to frame a tentative syllabus by a group of teachers in a city system is likely to precipitate war for two big reasons, violent championship of some "one and only" notebook course, or cherished text, and no less militant prejucice because of previous condition of servitude. Our botanist knows botany and must feature it, the chemist is just as sure of his ground, and the former physiographer must make his stock in trade the center of operation. Do not our texts, with few exceptions show the effects of such biases?

And yet, there is a sincere cry for help. The beginner in teaching, the overworked victim of too many subjects, or too full a program, the candid but finite specialist in science—anyone of these, called upon to present a course in general science to a hundred or more children— will need and demand aid and guidance. What are my aims to be, just what shall I teach, what text or texts shall I use, how can I presume to choose and eliminate wisely in the

presence of such a wealth of material? The only reliable point of departure in answering these appeals is clearly scientific study of the facts. It is not safe to follow the advice or plans of some one prophet with his panacea. Let us rather apply our vaunted scientific method to the experience and judgment of hundreds of teachers, and so discover some safe common ground as a foundation on which to build. Such is the attempt of the present study—may it be but a beginning.

It seemed, in view of the character of the problems and the absolute need for cooperation, that the questionnaire method, with all its shortcomings, was the only one possible. Accordingly a questionnaire was framed, intended to shed light on the questions already outlined. After criticism by a group of Cincinnati science teachers, a final draft was prepared. This formidable missive was sent to 150 teachers of general science about March 1. The mailing list was obtained thru the kindness of the Editor of General Science Quarterly. In selecting names from a larger number, two criteria were applied, first, a desire to obtain the widest possible geographical distribution, and second, to include mainly teachers in larger towns and cities. The latter limitation was due to a selfish desire to make the results more directly applicable to our Cincinnati problems, and must be kept in mind. In sending out these letters the writer acknowledges the support and aid of Dr. Hall-Quest and the School of Education of University of Cincinnati, and also of the commercial department of Hughes High School. The questionnaire in its final form is here printed in full.

### GENERAL SCIENCE QUESTIONNAIRE

1. Aims of General Science.

Please number, in order of their relative importance to you, the following commonly expressed aims of General Science. (write 1 in front of most important, 2 in front of next, please try to rank entire list as best you can.) Aims — General science in the first years of high school should give each pupil—

(a) A fund of valuable *information* about nature and science.
(b) The greatest possible understanding, appreciation and control of his everyday environment.
(c) *Preparation* and foundation for the later study of special sciences.
(d) Appreciation of the *applications* of science in modern industrial and social life.

(e) Training in the use of the *scientific method* in solving vital problems.

(f) A *vocational* survey of the sciences to guide and inspire plans for life work.

(g) *Interest* and motivation to vitalize his work and prevent his elimination.

(h) *Appreciaiion* of the unity and beauty of science, and of the work of its master minds.

(i) Training in cold, scientific thinking, carried on with strict self elimination. (Coulter)

2. Content—Selection of Topics.

Please mark each of the following topics which you consider *fundamental* to a high school course with the letter F, (preceding), and mark any others which you have tried and found successful as *supplementary* material with the letter S. If you have still other favored topics, write them below, lettered F or S. All these topics are, of course, to be treated in an elementary and popular way and adapted to the needs of the class.

LIST OF TOPICS

Systems of Measurement.
Force, power, and energy.
Molecular theory of matter.
Simple machines and law of work.
Air—chemical composition and combustion.
Air—physical properties.
Water—chemical properties.
Water—physical properties and mechanics of liquids—pumps.
Water supply and purification.
Household heating and lighting.
Ventilation.
Theory and laws of heat.
Light—nature and relation to life.
Sound—nature and relation to life.
Modern electricity and magnetism.
Coal, gas, and petroleum.
Combustion and fuels.
Density, specific gravity, and buoyancy.
Plumbing and household appliances.
Steam and gas engines.
Elements of physiology.
Foods—diet and digestion.
Hygiene and sanitation.
Clothing and textiles.

Everyday chemistry—salt, ammonia, nitrogen, carbon, carbon dioxide, fertilizers, paints, drugs, photography, etc.
Household chemistry—baking powder, fermentation, stain dies, flavors and extract, etc.
Elements, compounds, and mixtures.
Acids, bases, and salts.
Cooking and baking.
Iron, steel and other metals.
Drugs, narcotics, and alcohol.
Plant life and forms—elemmen. botany.
Animal life and forms—elem. zoology.
Bacteria, yeasts, and molds.
Evolution and heredity.
Common birds.
Trees and flowers.
Weather and climate.
Astronomy and the stars.
Physiography.
Soils and rocks.
Agriculture as applied science.
Gardening.
Cost of living—reasons.
Fireproofing and waterproofing—fire prevention.
Time and its measurement.
Transportation and railroads.

3. Special Problems of General Science.

A. Please check that method of instruction below which you have found most satisfactory, in use.

(a) Textbook—Assignments and recitations, based on one special book, chosen as text.

(b) Reference—Assignment, study and comparison of material in a number of texts or reference books, using notebook as supplement.

(c) Notebook—Basing course chiefly on careful development of topics in a full notebook in which are recorded results of class discussion and experiment, and of reading.

(d) Project—A grouping of the study around certain large but simple practical problems, in solving which the study of science is involved incidentally. (Twiss)

B. Please list here a few vital "projects", which you have found adequate and effective. (Space provided.)

C. Check below *your* commonest methods of using experiments.
Demonstrations by Teacher. Demonstrations by Pupils.
Individual or small group experiments—Inductive or leading to discovery of truth.

Individual or small group experiments—Deductive for proof or illustration of principles stated.

D. Name your preferred text in general science.
How many texts have you reviewed carefully?

E. Do you use supervised study?
If so, by what general plan? Check!
Alternate period, divided period, conference.

The returns were all in by the end of March, and it is very creditable to the spirit of the teachers selected, that replies to the number of 80 were received—over 50%. These returns were from 24 states in all, with Ohio and Massachusetts leading. They were distributed rather broadly, as follows—30 from the eastern states, 29 from the central states, 14 from west of the Mississippi, even to California and Oregon, and 5 from the southern states. With such an encouraging amount of material from such broad sources, it seems worth while to offer the results of the study as a tentative, initial attack on some vital problems of general science. The conclusions do not represent an individual opinion, we have had a surfeit of such evidence, but give us the more practical and reliable composite judgment of eighty teachers of actual experience. Taking up the first division, (1), let us examine this composite evidence as to aims. Why do we teach general science, or what should be the contribution of such a course to the life and development of a young secondary pupil? In my list, an attempt was made to analyze the aims most commonly expressed into distinct elements and so get a clear reaction as to their relative importance. The table of rankings and scores is given below.

In table I. page 451, the aims are arranged and numbered in order of their final ranking, and the first nine columns give the frequencies, or the number of teachers placing each aim in any given rank. An explanation of the total score in the last column is needed. It was obtained by multiplying the number of persons placing that aim in each rank by the number of the rank, and adding these products. As an example, for Aim (b)—Total Score=(53x1)+(10x2)+(7x3)+(2x4)+(4x5)+(3x6)+(1x9) =149. A moment's thought will convince, that whichever aim tends uniformly to obtain rank highest in the list, i. e. nearest first rank (1) will have the *smallest* score, and so on down the line. So the scores in last column are in ascending order, and the aims are in exact order of importance to this group. Should this method

## AIM OF GENERAL SCIENCE—As Ranked by Eighty Teachers.*

| The Aim of General Science is to give each child | | RANK—as given in 80 Questionnaires 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Total Score |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Understanding, appreciation, and control of his everyday *Environment*, | (b) | 53 | 10 | 7 | 2 | 4 | 3 | .. | .. | 1 | 149 |
| 2. Appreciation of the *Applications* of science in industrial and social life, | (d) | 5 | 23 | 15 | 17 | 11 | 2 | 5 | 2 | .. | 282 |
| 3. A Fund of valuable *Information* about nature and sciences, | (a) | 12 | 13 | 13 | 17 | 10 | 7 | 4 | 3 | 1 | 293 |
| 4. Training in use of the *Scientific Method* in solving problems, | (e) | 8 | 11 | 12 | 14 | 7 | 7 | 11 | 9 | 1 | 357 |
| 5. *Preparation* and foundation for later study of special sciences, | (c) | 6 | 6 | 10 | 11 | 14 | 8 | 12 | 11 | 2 | 400 |
| 6. *Interest* and motivation in school work to prevent his elimination, | (g) | 1 | 10 | 12 | 9 | 10 | 15 | 13 | 8 | 2 | 406 |
| 7. A *Vocational* survey of sciences to guide and inspire life work, | (f) | 1 | 7 | 9 | 8 | 17 | 16 | 13 | 6 | 3 | 421 |
| 8. *Appreciation* of the unity and beauty of science and of its master minds, | (h) | 1 | 2 | 5 | 5 | 10 | 16 | 11 | 27 | 3 | 506 |
| 9. Training in cold, scientific thinking involving self elimination, | (i) | 1 | 3 | 5 | 4 | 3 | 2 | 4 | 6 | 52 | 609 |

*Some teachers insisted on ranking the aims by groups, rather than in order from first to ninth. For example, one would mark several aims, such as (b), (d,) and (a), all *first*, (1), another group (2), and the rest all (3), etc. Such irregular scoring causes some of the ranks to total vertically slightly more than 80, and others less than 80, but does not at all affect the validity of the comparison.

seem unduly artificial, note that the aims ranked 1, 2, 4, 5, 6, 8, and 9, also show modal frequencies in their respective ranks—(b) is ranked first by 53 out of 80, (d) second by 23, and (i) last by 52 out of 80.

There were complaints of the difficulty of ranking *all* the aims, as requested, and some attempts required careful scoring. In fact, our natural and proper tendency is to combine certain of these aims, but for comparison and objective ranking some such method as the one used was necessary. Let us sum up, and combine results as indicated by the data. The primary and basic aims of general science in our high schools are to give each pupil the greatest possible understanding, appreciation, and control of his everyday *environment*—next, to acquaint him with some of the industrial and social *applications* of science—and to furnish as wide a fund of *information* about nature and science as time permits. Our watchwords seem to be—everyday environment first, then applied science, and information third.

Now for the troubled question of content. The marking of the list of topics as *fundamental,* (F), or *supplementary,* (S), led to a scoring of each topic as to the number of teachers who consider it fundamental, and the number who have rather found it useful as supplementary material. From a careful study of these scores, the following lists have been prepared. In the tentative list of fundamentals, all topics are placed which were marked F by a majority, or over forty, of those answering, while in the supplementary list are all topics, scored either F or S by over fifty out of eighty teachers. In both lists the topics are ranged in apparent order of importance and the scores are given in case other use could be made of the data.

LIST 1.—FUNDAMENTAL TOPICS, OR MINIMUM ESSENTIALS, OF GENERAL SCIENCE.

| | Scores— | F. | S. |
|---|---|---|---|
| 1. | Water—physical properties and mechanics of liquids. | 73 | 4 |
| 2. | Air—chemical composition, and combustion. | 71 | 6 |
| 3. | Air—physical properties and mechanics of gases. | 69 | 7 |
| 4. | Ventilation. | 63 | 15 |
| 5. | Household heat and light. | 62 | 15 |
| 6. | Water supply and purification. | 60 | 15 |
| 7. | Weather and climate. | 59 | 15 |
| 8. | Bacteria, yeasts, and molds. | 58 | 10 |
| 9. | Foods—diet and digestion. | 57 | 9 |

| | | | |
|---|---|---|---|
| 10. | Combustion and fuels. | 56 | 16 |
| 11. | Hygiene and sanitation. | 55 | 9 |
| 12. | Water—chemical properties. | 55 | 17 |
| 13. | Plant life—elementary botany. | 50 | 9 |
| 14. | Everyday chemistry (salt, ammonia, carbon, etc.) | 49 | 19 |
| 15. | Simple machines. | 48 | 13 |
| 16. | Force, power, and energy. | 47 | 11 |
| 17. | Animal life—elementary zoology. | 46 | 12 |
| 18. | Systems of measurement. | 43 | 21 |
| 19. | Acids, bases, and salts. | 43 | 21 |
| 20. | Elements, compounds, and mixtures. | 42 | 20 |
| 21. | Density, specific gravity, and buoyancy. | 42 | 18 |
| 22. | Electricity and magnetism. | 41 | 25 |

LIST 2.—SUPPLEMENTARY TOPICS—OPTIONAL MATERIAL.

| | SCORES— | F. | S. | Total |
|---|---|---|---|---|
| 1. | Household chemistry (soda, stains, etc.) | 35 | 30 | 65 |
| 2. | Coal, gas, and petroleum. | 39 | 25 | 64 |
| 3. | Molecular theory. | 40 | 22 | 62 |
| 4. | Light and its relation to life. | 40 | 20 | 60 |
| 5. | Astronomy and stars study. | 23 | 37 | 60 |
| 6. | Soils and rocks. | 37 | 22 | 59 |
| 7. | Steam and gas engines. | 20 | 39 | 59 |
| 8. | Plumbing and household appliances. | 32 | 26 | 58 |
| 9. | Sound and its relation to life. | 26 | 30 | 56 |
| 10. | Cooking and baking. | 23 | 33 | 56 |
| 11. | Elements of physiology. | 40 | 15 | 55 |
| 12. | Iron, steel, and metals. | 17 | 36 | 53 |
| 13. | Trees and flowers. | 23 | 29 | 52 |
| 14. | Theory and laws of heat. | 29 | 22 | 51 |
| 15. | Drugs, narcotics, and alcohol. | 20 | 31 | 51 |

LIST 3.—REMAINING TOPICS—THE LEFTOVERS.

| SCORES— | F. | S. | Total |
|---|---|---|---|
| Gardening. | 24 | 26 | 50 |
| Fireproofing, waterproofing, etc. | 20 | 30 | 50 |
| Clothing and textiles. | 16 | 34 | 50 |
| Cost of living. | 23 | 26 | 49 |
| Agriculture as applied science. | 17 | 32 | 49 |
| Common birds. | 19 | 28 | 47 |
| Physiography. | 21 | 25 | 46 |
| Time and its measurement. | 16 | 29 | 45 |
| Transportation and railroads. | 12 | 33 | 45 |
| Evolution and heredity. | 20 | 23 | 43 |

One outstanding feature of these lists is their harmony with our aims—the emphasis on everyday environment, industrial or

social applications and information. Traditional and organized science lines are lost sight of in these selections.

The same and practical order of the lists and the remarkable tendency to agreement in the group at large, in spite of evident bias in some cases, are bases for hope that the results may be of value to some.

The form of the topics was criticized severely in a few cases, as being cut and dried and traditional, leading only to a "hodge podge" system of combining special science material. This seemed however the surest or only way of getting at the facts. These topics are not original, but are a result of very careful study of the subject matter in most of the late texts, and of other analyses of their contents, such as that of Prof. H. A. Webb. (School Science and Mathematics—June, 1917.) These lists are simply a means of selection of material and scope, and determination of emphasis, in the only way in which we can meet on common, familiar ground. Such lists do not imply or support any special method of instruction, and the topics are of course to be presented in that way which seems best suited to various classes or individuals. Least of all do they preclude project or problem approach. As one reply aptly stated, "A project is the *topic* transformed into a problem which appeals to and grips the pupils." It should often be so used. The proper sequence of topics and their organization into units of instruction and recitation, the division of time and selection of material or problems within topics, are problems beyond the scope of this paper, and perhaps best left to individual solution.

But of what use then, are these lists or similar ones which may later be evolved or endorsed? First, they may form one of the best bases for a needed agreement on tentative syllabi, as in our own city. Where individual opinions clash, here is a common impartial statistical criterion. Secondly, the lists may afford some help to the classes of teachers who, like the writer, feel the need of advice on such knotty problems. In the third place, they may be of help to principals and supervisors, as well as to teachers, for the evaluation and criticism of texts or proposed notebook courses. It would seem that books omitting any large number of the topics in our first list must bear the burden of proof. Last and of most importance would be a continuation of such cooperative collective study from this perhaps crude attempt to fuller and abler studies which might serve as a basis for a liberal but sane

organization of "first year science" on a foundation of actual general experience.

This might seem the end of our task, but the writer could not resist the temptation, when sending out these letters, to seek light on several other important problems which he has been facing. Their meaning is fairly obvious, but the results are not so conclusive. The data as to method of instruction are as follows. Reference back to Part 3 of the Questionnaire will supply the exact description of each method scored.

A. METHOD OF INSTRUCTION

| | |
|---|---|
| (a) Textbook Method—one special text | 30 |
| (b) Reference Method—a number of books | 9 |
| (c) Notebook Method—developement by notes | 21 |
| (d) Project Method—grouped around large problems | 23 |
| Combination of (a) and (c). | 6 |

As might be expected, no single method seems to be universally used or endorsed. Many replies, tho not as many as one might expect, indicated wholesome combination of (a) and (c), (b) and (c), (b) and (d). etc., and we may agree readily with some writers that no one of these methods should suffice for all types of work. Without intruding an opinion as to (c), some notebooks I have known seem to warrant a warning against making a fine and copious notebook an end rather than a means. Remember our dominant aims, and subordinate method to those ends. Sometimes children must spend so much time writing that they have too little chance to think or talk, and take too much by dictation—fool's gold.

The fine showing of the project method, and the rampant enthusiasm of the replies of some of its exponents, were tested by the request to list a few favored projects. This call was answered by 35, so evidently some use projects as a secondary method. The lists of projects prepared from these answers would alone form the basis of a paper. They vary from good to bad, but can be roughly divided into two groups. About 15 showed by their lists of projects a realization of the significance of that method as advocated and illustrated by Woodhull, Barber, Twiss, et al. The other 20 at least did not present real projects and the implication is that they fail utterly to differentiate a project from a topic. A few examples from each group will illustrate fairly.

B. 1. REAL PROJECTS.

Making a fire extinguisher.
Making an electric bell.
Erection of 75 ft. flagpole.
How to build a fire.
How we save food from spoilage.
How is bread made?
A star project, launched by means of some special phenomenon.
The leaf as a factory.
Story of a lump of coal.
The story of my suit.
A pinch of salt.
Study of a match.
How are messages sent by telegraph?

2. PSEUDO PROJECTS—Topics in form.

Air—Composition, ventilation, and combustion.
Heat, its source and benefits.
Bacteria—disease, infection, etc.
Water supply.
Common machines.
To light our school.
Thermostat.
Illuminating gas.
Air.
Sanitation.
Weather.
Safety first.
Camera.
Soil.
Fuels.
Meters.

It seems as tho these lists, and the numerical showing, indicate, as do some of our best articles on the subject, that the project method of teaching is winning its way, and is of real value, but is still in process of slow evolution. It is scarcely a panacea for all ills, nor a safe exclusive method for an overworked teacher or a beginner.

Next comes the method of using experiments in general science. I append the table of scores.

C. TABLE FOR METHOD OF EXPERIMENTATION.

1. Demonstrations by Teacher. . . . . . . . . . . . 63
2. Demonstrations by Pupils. . . . . . . . . . . . . 19
3. Individual or small group experiments inductive in form ..........................36
4. Individual or small group experiments deductive in form-proof or illustration. . . . . . . 15

It is very probable that the use of one or other of these methods is often a matter of expediency—of time or room available and of limited equipment. Ideally, as some suggested, we should employ every one of these methods as found most effective for the purposes outlined before, but only as real means to those ends.

Many of the liberals who occupy a middle ground feel unwilling to abandon altogether the use of texts, even in general science. When they are the fruits of years of careful work and experience of able, practical school men, they are of inestimable value to the rank and file of ordinary teachers, as reference material, if not for exclusive use. Our great need in first year science, is an ideal text, based on a recognized foundation of aims and content, but it must be the result of experience and evolution, not of theory and enthusiasm alone. I give the list of texts mentioned as favorites without comment.

D. FAVORITE TEXTS—Hessler—13, Barber—11, Caldwell and Eikenberry—11, Clark—10, Elhuff—7, Snyder—4, Fall—2, Pease—2.

Many teachers indicated, one profanely, that they found none of the present texts satisfactory, which is not surprising in the abscnce of agreement on aims and content. At present, reference to several texts seems to be a common method, but the following figures show a deplorable failure to review fairly and thoroly a sufficient number of the books already available.

D. NUMBER OF TEXTS REVIEWED CAREFULLY.

| | | |
|---|---|---|
| 1 Text —0 | 5 Texts— 6 | 9 Texts— 2 |
| 2 Texts—0 | 6 Texts—16 | 10 Texts— 9 |
| 3 Texts—5 | 7 Texts— 6 | 11 Texts— 1 |
| 4 Texts—3 | 8 Texts—10 | All Texts—15 |

My last question was in regard to the use of supervised study, another symptom of progressivism. It seems a very natural means of introducing children to general science, especially in the co-

operative framing of projects and problems, and in experimenting. I surmise that many of our friends if they investigated the subject, would find they had been using study supervision, tho not distinguished by that name. I submit the data which are obvious.

E. Do you use supervised study. Yes—38. No—38.
General Plan of Study Supervision.
Divided Period—24, Conferences—10, Alternate Period—2.

In closing let me acknowledge my indebtedness, for inspiration, support, or aid, to Dr. A. H. Hall-Quest of University of Cincinnati, Dr. L. V. Roos of University of Washington, to the commercial department of Hughes High school, and to the editor of General Science Quarterly, but most of all to the eighty co-workers who answered a rather lengthy questionnaire.

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# A Remedy for the Congestion of Subject Matter in General Science.

M. Louise Nichols, Head of Dept. of Science, South Philadelphia High School for Girls.

Listening not long ago to a debate carried on by teachers of English in high schools and colleges, I was struck by a similarity in the nature of the controversies which rent them and those disturbing the peace of laboratories of science. The fiercest battle raged about the question of the practical versus the ideal as legitimate aims in teaching. There were those among the disputants who apparently believed that no sordid details of material benefits to be derived should come between the mind of the student and the contemplation of "the best that has been thought and said" in the world's history. They referred to "business English" with the same air of disdain that the corresponding type of science teacher uses in speaking of "grease spot chemistry".

It is perhaps not difficult to comprehend this state of mind and to allow for it. The devotee of perfection of style has spent hours in the study of masterpieces of English and in the effort to approximate his own writing to their lofty standards, while the earnest seeker for scientific truth has schooled his mind to minute observation, precise measurement and strict application of logical process-

es. Holding these high ideals constantly in view in their own work and realizing so keenly the time and patience required to attain them, attempts to divert their energies into what seem to them meandering byways are naturally resented. Back of their reluctance, too, and less often coming to the light in public discussions, I can not help suspecting personal preference. Confronted with the task of instructing some dozens or hundreds of immature minds the extreme classicist, be he an instructor of English or science, feels that to be successful he must teach whole heartedly and with enthusiasm. Practical applications he loathes and therefore follows the path of least resistance and continues to direct the attention of his pupils to the "best that has been thought and said in literature and science. The more utilitarian minded realist may yield to the same temptation of following personal inclination and neglect entirely the broader or more abstract aspects of the subject he teaches. "Essay English" or "formula chemistry" fill him with impatience, therefore he avoids them.

Lifted beyond the region of personal inclination and recrimination, the question becomes, however, real and important to the present and future lives of school boys and girls. Is the movement now permeating all branches of education permanent? this movement towards a more constant, direct and intimate contract between—I was going to say real life and school life—but is seems absurd that school life should not be real and the question in the asking answers itself. Surely it is a movement that has come to stay and is bound to progress, not, as extremists would have us believe, one of the many fads and eccentricities which hamper human endeavor.

If, then, as we are told on all sides, the present duty of school masters and mistresses is more than ever to train boys and girls for a speedier efficiency and a more complete harmony with the keynote of modern progress, social service, it behooves us to sternly suppress private preferences and to survey the field with all the impartiality we can muster. As teachers of science we should ask ourselves,—What kind of science is at present taught? Is it fulfilling expectations? Are any modifications needed to make it more effective in the future? If so, in what direction should improvement be made? Do we need more emphasis on things practical or on mental discipline and abstraction? Is it possible profitably to combine the two? I have tried for my own purposes to find answers

to these questions and welcome the opportunity to lay the results of my inquiry before the readers of the GENERAL SCIENCE QUARTERLY hoping that some of them, from their experience, may be able either to reinforce or to correct my conclusions.

The science prevailingly taught is, as we all know, generally divided into such special subjects as physics, chemistry, biology (often subdivided into botany, zoology and physiology) and geography. In high schools, public and private, and in the colleges, laboratory work is the rule, often carried out by the students from printed directions and illustrative of certain scientific principles considered desirable for them to know. Many of the text books used open with a chapter in which fundamental conceptions are defined (matter, density, weight, elements, compounds, etc.), proceed in the following chapters to the explanation of certain laws involving these conceptions and give, either incidentallly or at the end of each chapter, illustrations of the applications of these laws,

Within the last few years, in response to the growing demand especially in manual training, trade and vocational schools, for a closer relation to actual life, text books and laboratory manuals have been appearing which subordinate principles and definitions and deal more directly with daily experience, but for general high school courses a modification of the method pursued in colleges is still the rule.

An attempt to answer the question as to whether this way of presenting the subject to high school students has met with success has been made by Elliot R. Downing in articles published in the General Science Quarterly for November, 1917, and in Science for October 12th, 1917. By means of figures taken from the Report of The United States Commissioner of Education, he shows that there has been a decrease, during the period 1910-1915, in the percentage of students taking the "old line subjects" in science which is not compensated for by the percentage taking more recently introduced subjects such as agriculture and domestic science and draws therefrom the conclusion that "it is fairly evident that the high school science course is in some way out of joint with the times." While this may in truth be the case, it does not necessarily follow from the figures of the United States Commissioner. In the year 1909-1910 the percentage of high school students enrolled in science was 91.99, in 1914-1915 is was 81.16. This does not of

course mean that fewer students were taking science in the latter year. On the contrary it means that more were, for during the period 1909-1914 the total high school enrollment increased 45.1%. For every 1000 students in high school during 1909-1910 there would be in 1914, 1451, therefore for every 920 pupils studying science in the former year there would be, in the latter year, approximately 1175. It does nevertheless mean that for approximately 276 out of every 1000 science is considered to be of little if any value. A possible explanation for this may lie in the fact that an increasing number of students are entering commercial courses and the time required for subjects more directly related to office practice and the making of a living by clerical work crowd out from the curriculum scientific subjects along with the classic languages and masterpieces of English literature.

Concerning the interest of the pupils themselves it is hardly fair to use these statistics as a test, since the opportunities for election of subjects in high school are extremely limited and often more apparent than real. The figures are more indicative of how far the makers of curricula consider science important. Perhaps more light may be thrown on the question of student interest if the proportion of students electing science in non-technical colleges is compared with the proportion election other subjects. If science courses in high schooı have made the subjects vital and have aroused the desire to kno. more about it the proportion continuing its study in college should be relatively high.

The necessary information is furnished by the investigations of Dr. Frederick C. Ferry of Williams College supplemented by those of W. LeConte Stevens of Washington and Lee University. (Science Oct. 24th, 1913 and Jan. 1st, 1914). Dr Ferry tabulated the registration of academic students taking various subjects in eighteen representative colleges and universities, coeducational as well as those exclusively for men or women. The subjects fell into three groups: I. Languages (classic and modern). II. Humanities (including English). III. Sciences (including mathematics). Reduced to "student hours of instruction" and calculated in percentages, Dr. Ferry's results were for the I. and III. groups respectively 24.50 and 28.72%, for Group II. 46.78%. Prof. Stevens, from these results, derived a value P expressing numerically the average demand for any given subject in the eighteen institutions. The average value of the sixteen subjects represented in

the table was a little over 6 which was therefore taken as a "rough standard for comparing the student demand for different subjects". This average was not reached by astronomy, Greek, geology, physics, Bible study, Latin, Political science or biology. It was reached by philosophy and chemistry and exceeded by economics, modern languages, mathematics, history and English. Plainly science in the colleges is not highly popular. It is interesting to note that chemistry, which appears as the most popular or the least unpopular of the sciences in college is also the only science which in the Commissioner's Report shows a slight gain in the high schools in the period 1910-1915, namely from 7.13% to 7.63%. Chemistry is likewise the subject which earliest responded to the demand for closer approximation to practical living.

Evidently science in the high schools has not been an unqualified success, if the interest shown by the students be a test. Close on the heels of this demonstrated fact comes the query,—What is the trouble? In a scientific age can not, must not the subject be made of vital interest and importance to the rising generation? How can it be done? This is the problem which the editor of the GENERAL SCIENCE QUARTERLY and his collaborators have clearly seen and are striving to solve. General Science, being a new departure and therefore comparatively unimpeded by tradition, offers an opportunity for the experimental solution of the question and experiments are being tried wherever it has been possible to introduce general science into the curriculum. This is perhaps an explanation and a compensation for the chaotic condition of expert opinion on the subject. I gather from my reading of articles that have appeared in this journal that whenever the experiment has been tried of presenting to the children problems such as arise in the course of their daily experience and of showing them how these problems may be solved by the application of "organized common sense" not necessarily subdivided into chemistry, physics or biology, that interest has been shown and curiosity aroused. Whatever criticisms have been leveled at this method have not been on the score of lack of an appeal to the real needs of the children. They have rather been that general science tends to be overcrowded and the material arranged without sufficient coherence. That the children's attention is held and their efforts stimulated is something very valuable gained. Coordination and rearrangement may be expected to follow with increasing experience and repeated experiments.

Heretofore this method of applying observation, experiment and reasoning to the affairs of everyday life has not extended beyond the 9th Grade. If, however, it has proved itself of value thus far and teachers are struggling with the overabundance of material thus secured, why not extend the same method to the remaining years of high school, why not continue to deal with daily experience as it is presented and not artificially confined within the boundaries of the special sciences? Are there essential advantages to be derived from studing chemistry as chemistry, biology as biology, etc. that would be foregone by such an extention and which would not be compensated for by the increased interest which the specialized sciences have not shown themselves able to maintain? The answer to this depends largely upon what it is believed desirable that high school boys and girls should get from their science study. The method of presenting the subject which has been in general use for the last twenty-five years has come down to the high school from the college and the college entrance examinations accurately guage what it is that the colleges require from the instruction of the high school. The following are questions taken from the groups of five, all of which must be answered and which are supposedly considered essential in the entrance examinations of 1916 in chemistry;—Define the terms "molecule", "atom", and "ion". State Avogadro's hypothesis, and show how it guides the chemist in determining molecular weights. Calculate the percentage of oxygen in crystallized copper nitrate.

College professors of science might be disposed to doubt whether the proposed method would give students sufficient familiarity with laws, definitions and calculations. On the other hand those directly engaged in teaching high school science and striving to fit the children for the responsibilities of actual life, which are likely to be unusually heavy in this century, will be inclined to inquire whether such familiarity can not profitably be postponed until college years while the high school devotes its energies to familiarizing the children with the real nature of life's daily experiences and the kind of observation and thinking which will enable them to understand and adapt themselves intelligently to its concrete situations.

Those who have taught students of high school age can not fail to have noticed that the minds of the majority are essentially

concrete. The often heard complaint "It was like pulling teeth to get that from the class" usually comes ofter a struggle for a definition of some abstract idea or proposition. The Greeks among high school students are few. They are chiefly Romans and Phoenicians and assimilate only the tangible and the useful. It may be said however, that chemistry as chemistry or physics as physics may be made tangible and useful and that there is no necessity for disturbing the traditional boundaries between the sciences. That special sciences can be so presented is without doubt true. Very excellent text books have appeared which demonstrate it. Nevertheless if we wish to bring home to the extremely concrete minded average high school student with the greatest possible emphasis the application of scientific principles to daily life, we must reproduce as nearly as practicable in school the actual conditions of real life where phenomena are rarely purely physical, chemical, etc. Every abstraction from the real lessons by so much the appeal and the vividness of the instruction.

If we cast aside then our inherited attitude towards the teaching of science and attempt without bias to discover the concrete experiences which are best adapted to give young people the sort of knowledge and training which will best fit them to appreciate the part that science plays in modern life, we shall be less likely to include in our courses information little used and therefore soon forgotten after graduation.

Two years ago I undertook, as head of the department of science in the South Philadelphia High School for Girls, to plan courses in science which would, as far as possible, meet the needs and interests of young girls. I gratefully acknowledge that the undertaking was begun under unusually favorable circumstances. The school was new and headed by an exceptionally liberal minded principal. The curriculum of the high schools in Philadelphia had not become rigidly standardized and, last but not least, I had the cordial cooperation of the other teachers in the department.

The first year of science is required of all classes and consequently must be adapted to a variety of pupils, i. e., those leaving school at the end of the first year as well as those taking commercial, home economics, academic and college preparatory courses. It seemed advisable, therefore, to give in the first year an introductory course which would furnish those who take no more science with some idea of the method and the fundamental inter-relations and applications of the sciences, while at the same time laying a foundation for more

advanced courses. It is pursued for five school periods a week and aims to give the children in the simplest possible way an insight into the real nature of such universal features of the environment as water, air, metals and mineral salts, how their properties make them of use to us in daily life, how living things in the form of green plants utilize them to make organic substances also useful to us, how other living things (fungi) break up organic material into simple substances again and cause decay, how animals depend on substances elaborated from the environment by plants for their existence and finally how certain forces as distinct from the material of the environment aid living things, man as well as animals and plants, in making use of the materials of the environment and in adapting themselves to it. I have found that this results in giving the children a familiarity with the commonest of the elements (carbon, oxygen, nitrogen, sulphur, phosphorus, etc.), the simplest of their compounds (carbon dioxide, oxide of iron, water, quick lime, etc.) and of the part they play in every day life (burning, breathing, boiling a kettle, rusting of iron, etc.) They appreciate also the part that plants play in making food for us and gain an elementary knowledge about their manner of life which can be practically applied in home and school gardening. The study of animals gives them a first hand acquaintance with the fundamentals of structure, physiology and reproduction which serves as a background for human hygiene. They also obtain an idea of what is meant by heat, light, electricity and sound and of the way these forces operate in such common occurrences as the ringing of a door bell, the boiling of water, the heating and lighting of a house.

The second year course I have called Household Science and have divided it into four main topics, i. e., Fuel, Building Materials, Food, and Clothing. To the development of these topics all of the sciences contribute. For example, biology aids in the understanding of the origin of peat and coal, of the properties and preparation of lumber, of the production and preservation of food and of the source and character of textile fibers, physics throws light on the proper management of a fire, the production of gas, the utilization of materials for the construction of buildings, tools and cooking utensils, while chemistry explains many of the processes used in the preparation and cooking of food and the manufacture of building materials and clothing. Necessarily there is constant reference to the information gained during the first year, not only a review of

the facts, but further applications of them and the addition of new but related knowledge. By the end of the second year, the formerly strange hydroxides, acids and salts with names and formulae difficult to remember have become more or less familiar acquaintances, bacteria and insects are seen more clearly to be both friend and foes and the practical value of heat and electricity are realized more completely.

Since the school is but two years old, the third year course has not yet been given. It is proposed that it should deal with the relations of science to undertakings which serve the needs of the community and may appropriately be called Civic Science. Such subjects as water supply and sewage disposal, sanitation, weather prediction, telephone and telegraph service, transportation, sources of power, printing, public recreation would come under this head. Again all of the sciences would be drawn upon in developing the topics and frequent incorporation of the work of previous years would be involved.

A discussion of the pollution of the water supply and its purification will necessitate a review of the previous work on the properties of soils, filtration, solution, hard and soft water, and the action of bacteria in decomposing organic matter and forming nitrates, while introducing as new material the simpler chemical tests for impurities and the geological formation of the Schuylkill and Delaware River water sheds. Closely connected with the subject of water supply will be the study of waste disposal and the value of sanitary plumbing. To understand this and the mechanics of the water supply, the students will need to become familiar with laws of physics pertaining to water and air.

In taking up the precautions practised by city authorities to prevent the spread of desease and to preserve human life, what knowledge of bacteria the students have already acquired will be further extended and correlated with the chemical nature and the action of disinfectants and antiseptics. Cultures of bacteria from various localities will serve to illustrate the danger of infection and the methods used to isolate different strains of bacteria. If time permits some of the more important devices used for diagnoses and disease prevention, such as x-rays, vaccination and serum injection will be included.

A review of evaporation, condensation, convection, etc., will make plain the use of weather instruments and the significance of weather

charts, while conditions favorable or unfavorable to plant life must be recalled in discussing the importance of weather prediction.

The subjects of transportation and sources of power, since they are in practice so inseparable, must be considered more or less closely in relation to each other. These as well as the study of the means of communication, ought considerably to enlarge the student's knowledge of physics and its most recent applications.

The same end would be served by a study of the acoustics and lighting of places of public amusement, of stereopticon, moving pictures machines, instruments of the orchestra and phonographs.

Not yet having given the third year course I am unable to say how much of this sort of ground can be covered, but, judging from the experience of the first two years, possibilities for subject development will be elastic and time limit rigid.

Altho the approach to the subject in the first three years is invariably through practical needs and interests, the theoretical side is not entirely neglected. Molecular and atomic theories, catalysis, hydrolysis, allotropy, the writing of formulae and equations, the distinction between force and work, the laws of work, the laws of conservation, of pressure in liquids and gases, the laws of reflection and refraction, the wave theory, the nature of noise and musical tone, and other more or less theoretical matters are touched upon in explaining phenomena. It is intended, however, in the fourth year to go more thoroughly into the nature of scientific theories and hypotheses, the intellectual necessities that gave rise to them and the effect they have had on the world's progress. Within the five periods a week allowed the ground covered would necessarily be limited, but it is hoped that it will be possible to give the class some idea of present theories concerning the constitution of the earth and its position in the solar system, of the gradual development of the conceptions which underlie these theories, of the men who devoted their lives to giving these conceptions a firm foundation and of the difficulties they met and overcame. This may be followed by an account of how we have arrived at an idea of the age of the earth and of the forces which have shaped it and of our gradual appreciation of the real nature of earth, air, water and fire. It is intended also to show how theories concerning living things have been developed and of the immense influence they have had on modern thought and action as well as to outline the theoretical basis of some of the most important inventions.

I have been moved to plan such a course as a climax to the high school science studies, not only because it will afford numerous opportunities to review and to bring into broader relations concrete facts and simple generalizations already assimilated, but also because of the need so often felt by workers in theoretical science of a wider knowledge by the public of the value of their labors, of their difficulty and of the time they consume. To prevent the course from becoming bookish and remote exercises will be required of the students, such as observations of the heavenly bodies, of the effects of wind, waves and weather, examinations of fossils and different kinds of rocks and as far as may be practicable experiments illustrating the more important laws or hypotheses.

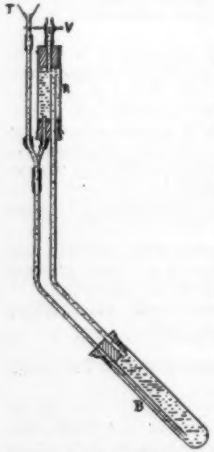
The four years course which I have described is taken by academic students, except college preparatory students. Commercial students are required to take the first year of science and, in the fourth year, one half year of commercial geography. They may also elect the second year of science if they so desire. Inasmuch as the subject of commercial geography is treated under the topics Fuel, Building Materials, Food and Clothing with regard to the factors which influence the areas of their production, distribution and sale, it is a distinct advantage to the commercial students to have had the foundation which the second year of science affords. For the hygiene required of all students in the last year, the work of the preceding years gives also a background, as by that time such subject as the nature of oxygen, carbon dioxide, osmosis, acids, bases, salts, carbohydrates, fats and protein, solution, emulsion, outlines of anatomy, physiology and reproduction, qualities of textile fibers, chemistry of cooking, etc. are familiar.

Altho the course is now only in the second year of its trial, I have as yet seen no reason to think that we have chosen the wrong path. I feel sure that the general science idea has virtues which are worthy of application beyond the ninth grade and that such an extension of its scope will go far to relieve the congestion and incoherence universally complained of at present. With more time in which to cover the field, the various topics will fall more easily into their natural relations. On the other hand, the greater precision of method and abstraction of ideas required by the specialized sciences as now taught and which have but little appeal to the average high school student will find their proper place in the college curriculum.

# Hot Water System: Demonstration Apparatus.

By Percy E. Rowell, San Jose High School, California.

The drawing is almost self-explanatory. The boiler, B, is a 8x1-inch test tube, fitted with a two-hole rubber stopper. The radiator, R, is made from a similar test tube by holding the bottom of the tube in a flame until hot, and then blowing it out.




If the hole so made is enlarged while hot, by means of an iron rod, it may be fitted with a one-hole rubber stopper. The overflow, or expansion tank, T, is made from a three-inch funnel. The "Y" connection is a glass "Y." The heavy lines indicate pieces of rubber tubing. The valve, V, is an ordinary pinch-cock. The long tubes are ¼-inch glass tubing.

Demonstration:

1. Filling the System—Add cold water to the tank. Water does not enter the system until valve is open. Why? Although the radiator is nearer the tank than is the boiler, the latter is filled first. Why? When the surface of the water reaches the top of the radiator, close the valve. The water should then stand at the same level in the tank pipe as in the radiator.

2. Heating the System—Apply the Bunsen flame to the lower part of the boiler. Although the long tube is nearer the bottom than is the short tube, the water becomes hot first in the short tube. Why? The hot water moves up the top tube. Why does it move? The water rises into the tank. Why? Is there more water in the hot system than in the cold system? Bubbles of air collect in the top of the radiator. Where do they come from? If the air is not permitted to escape through the valve the radiator will not become hot. Why? If the water boils the steam will escape through the tank. How would a system without a tank act?

3. Cooling the System—Watch and explain all that happens. What would happen if the tank was very small?

# General Science Book Reviews.

*Elementary General Science.* By D. R. HODGDON. HINDS, HAYDEN & Eldredge. 575 pages. 395 Illustrations.

The science material treated in this text centers around the home.

Two important considerations have been kept in mind in evolving this book; namely, that science information and the development of interest are both valuable assets. These two things are successfully met by the large volume of interesting material which has been assembled. The pupil finds the same incentive to look this book through as he does to read the popular science magazines but added to the interest which has been secured is a real science discussion which is too often lacking in the popular magazine.

Evaporation, moisture and the atmosphere are treated in a simple elementary way making special application to cooling processes and to weather. Chapters on heating and oxidation are followed by practical treatment of foods. This is followed by chapters on water, germs, and diseases. The first nine chapters have rather close relation to each other and are well organized. The last six chapters are less closely related and touch upon light, electricity, sound and music, the universe, machines and work, and "Safety First".

"Nostrums," "Safety First," and "Emergency Treatment," treated here, are subjects not found in other texts.

It will be seen that the book is physical science almost entirely and while it will find many teachers ready to welcome it on that ground, there will be some who will feel the lack of biological material.

Numerous illustrative experiments are given and stimulating thought questions are introduced at frequent intervals.

*Course of Study in General Science.* School Document No. VII, 1917, Boston Public Schools.

This pamphlet of forty-one pages was prepared by a council of eleven Boston teachers, representing the elementary, the high and normal schools. Work is provided for ninety forty-minute periods, in each of grades VII, VIII, and IX.

Gardening is suggested as an alternative for about one half of the time in grades VII and VIII for some schools. Type lessons are outlined.

The general plan of work is stated as follows:

Project

1. Problem stated and analyzed.
2. Materials and apparatus.
3. Directions.
4. Questions leading to
   (a) Observation
   (b) Results
5. Application to guide pupil's activities towards personal experience and home needs.
6. Notebook record.
7. Additional problems related to the original problem.

There are many helpful suggestions in the manual. The Council has made a substational contribution towards the solution of our ever present problems of general science.

## Useful Pamphlets.

The folllowing list of pamphlets is submitted by Mr. A. H. Morrison of Boston Mechanics Arts High School:

*Bulletin* 1415 Fire Alarm Signal Co., Boston, Mass.
*History of Light* Welsbach Co., Phil., Pa.
*Characteristics and Care of Storage Batteries*
*Ignition. Information Book (Ignition and Lighting)*
National Carbon Co., Cleveland, O.
*Ignition and Spark Plug Talks*
Champion Spark Plug Co., Toledo, O.
*How to Read Your Electric Meter*
Gen. Elec. Co., Schenectady, N. Y.
*Experimental Electric Testing by Students*
*Elementary Electric Testing, Monograph B2*
Weston Electrical Instrument Co., Newark, N. J.
*Farmers' Bulletins, U. S. Dept. of Agric., Washington, D. C.*
*Bulletins of the Bureau of Standards, Washington, D. C.*
*Witherbee Instruction Book*
Witherbee Igniter Co., 541 W. 43d St., N. Y.

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## Books

*Health in Home and Town,* by Bertha M. Brown, D. C. Heath & Company, 312 pp.

This is a very valuable book. Not only does it furnish material on science related to good health of the pupils of Junior High age; but it is suggestive to teachers. Many of the chapter titles suggest a general science text as much as they do a hygiene text, for example, "How to Ventilate the House," "How to Warm the House", "How to Light the House", "Running Water in the House", "How to Care for the House", "City Food Supply", "City Water and Ice", "Diseases Dangerous to the Public Health."

*Sanitation and Physiology.* John W. Ritchie, World Book Company, Revised edition, 1917.

Part 1. Sanitation, 216 pages; Part 2. Human Physiology, 308 pages.

This gives an exceptionally complete course in hygiene, sanitation, and physiology.

In part 1 a summary of "Points to be Remembered" is found at the chapter ends. In part 2 each chapter is followed by a list of pertinent questions which give a thorough review of the chapter.

This book is adapted to pupils in higher elementary and lower high school grades, and is written in the style to interest them.

# Science Articles in Current Periodicals.[1]

ACETYLENE

Acetylene Trench Gun, Ill. Pop. Sc. Mo. 92:586. April 1918.

AIRPLANE

The Technical History of the Airplane. Capt. F. M. Green. Sc. Am. Sup. (No. 2200) 85:130-131. Mar. 2, 1918.

AIRSHIPS

Baring the Super-Zeppelin's Secrets, Ill. Carl Dienstbach. Pop. Sc. Mo. 92:372-378. Mar. 1918.

ALCOHOL

Grain Alcohol from Garbage. Ill. World. 29:128. Mar. 1918.

ANTISEPTICS

Marvels in the latest Antiseptics. Cur. Opin. 64:336. May, 1918.

ARGENTINA

The Pampa of Argentina, Ill. W. S. Power. Geog. Rev. 5:293-315. Apr. 1918.

AVIATION

Aerial Torpedoes: Dropping Death from Skies. Ill. Carl Dienstbach. Pop. Sc. Mo. 92:518-520. Apr. 1918.

The Effect of High Flying. Sc. Am. Sup. (No. 2206) 85:227. Apr. 13, 1918.

Eyes in the Air. Ill. Henry Bruno. Pop. Sc. Mo. 92:508-511. Apr. 1918.

Mild Weather and the Air Man. Ill. Pop. Sc. Mo. 92:722-725. May, 1918.

Flying on Wings of Spruce. Ill. E. A. Sterling. Am. For. 24:133-139. Mar. 1918.

War Aviation. B. C. Hucks. Sc. Am. Sup. (No. 2209) 85:284-285. May 4, 1918.

BIRDS

The Humming Birds and Swifts. Ill. A. A. Allen. Am. For. 24:160-164. Mar. 1918.

The Kingfishes. Ill. A. A. Allen. Am. For. 24:91-94. Feb. 1918.

The Owls. Ill. A. A. Allen. Am. For. 24:219-224. Apr. 1918.

BOMBS

Dealing Death with Death Bombs. Ill. L. E. Darling. Pop. Sc. No. 92:562-567. Apr. 1918.

BURNS

The Treatment of Severe Burns with Ambrine. C. G. McMullin, M. D. (From Gen. Elec. Rev.) Sc. Am. Sup. (No. 2203) 85:190. Mar. 23, 1918.

CANAL

N. Y. State Barge Canal, Part II. Ill. Stanley W. Todd. Pop. Mech. 29:738-742. May 1918.

COAL

Artificial Anthracite. Lit. Dig. 56:9:23. Mar. 2, 1918

Our Annual Coal Drama. Ill. L. E. Darling. Pop. Sc. Mo. 92:530-536. Apr. 1918.

The Problem of the Coal Supply. Edw. W. Parker. Jo. Franklin Inst. 185:445-460. Apr. 1918.

How Much Heat is in Your Coal? Ill. C. Armstrong. Ill. World 29:34-35. Mar. 1918.

COLOR BLINDNESS

Color Blindness. (with diagrams). P. A. Maxwell. Gen. Sc. Quar. 2:410-414. Mar. 1918.

CONCRETE

Recent Progress in Concrete Construction. Ill. H. C. Campbell. Coml. Am. 14:9-10; 31-33. Mar.-Apr. 1918.

1 See Magazine List, p. 425, Gen. Sc. Qr. for March.

CRUTCH
A Crutch with Rockers. Ill. Lit. Dig. 56:15:24-25. Apr. 13, 1918.

DAYLIGHT SAVING
Hooverizing Daylight. Pop. Sc. Mo. 92:546-548. Apr. 1918.

DIVINING ROD
Divining Rod. A. J. Ellis. Sc. Am. Sup. (No. 2200) 85:138-139. Mar. 21, 1918.

DREDGING
Modern Suction Dredging. Ill. Chas. E. Fowler. Sc. Am. 118: 356. Apr. 20, 1918.

EGG TESTING
Testing Eggs by Photography. Ill. Jacques Boyer. Sc. Am. 118: 362. Apr. 20, 1918.

ELECTRICITY
Principles of the Electro Magnets. Peter J. M. Clute. Pop. Sc. Mo. 92:469-471. Mar. 1918.
Theory and Fundamental Principles of the Condensor. Ill. Peter J. M. Clute. Pop. Sc. Mo. 92:629-630. Apr. 1918.
Principles of the Induction Coil and Transformer. Peter J. M. Clute. Pop. Sc. Mo. 92:793-795. May 1918.
Economic Industrial Applications of Electricity. N. T. Wilcox. Sc. Am. Sup. (No. 2201) 85:146-147. Mar. 1918.
Electro-Static Experiments. F. Von Lichtenow. El. Exp. 5:768. Mar. 1918.

ENGINES
Propulsion of Ships. Eskilberg. Jo. Franklin Inst. 185:317-332. Mar. 1918.

EQUILIBRIUM
How the Concrete Ship Turns Over. Ill. Lit. Dig. 56:5:18. Feb. 2, 1918.

EXPLORERS
American Explorers of Africa. E. F. Balche. Geog. Rev. 5:274-281. Apr. 1918.

EYE
Accomodation and Chromatism of the Eye. The Optical Jo. and Rev. of Optometry. 41:2:94. Jan. 3. 1918.

FARM MACHINERY
Mechanical Equipment of the Farm. Ill. B. P. Potter. Sc. Am. 118:193. March 2, 1918.

FISH
A Method of Fish Study for Beginners. G. C. Embody.
The Physiognomy of Fishes. R. W. Shufeldt,
The Salmon. J. R. Traver.
Nat. St. Rev. 14:4 (Fish number) Apr. 19, 1918.

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Foods for Fighters Lit. Dig. 56:8:22 Feb. 23, 1918.
Food for All. A Fundamental War Problem. Ill. Sc. Am. 118: 310. Apr. 6, 1918.
The Palate of Civilized Man and Its Influence on Agriculture. David Fairchild. Jo. Franklin Inst. 185:299-316. Mar. 1918.
Drying Vegetables and New Conservation Move. Ill. Arthur L. Dahl, Sc. Am. Sup. (No. 2200) 85:134-135. Mar. 2, 1918.
Milk and Cheese Compared with Other Foods. Ill. World 29: 428 May 1918.
Food Values. Lit. Dig. 56:9:28. Mar. 2, 1918.
The Soya Bean. Ill. Hudson Maxim. Pop. Sc. Mo. 92:686-688. May 1918.
Our War Sugar Bowl. J. W. Herrington. Pop. Sc. Mo. 92:710-711 May, 1918.

FOODS

Peanuts as Food. Lit. Dig. 86:15:22 April 13, 1918.

The Peanut's Bit. J. D. Stuart. Country Life. 33:660. Apr. 1918.

Peanuts for Oil Production. Agri. Dig. 2:930. Apr. 1918.

Modern Margarine Technology. W. Clayton. Sc. Am. Sup. (No. 2200) 85:134-135. Mar. 2, 1918.

Saccharine as a Sugar Substitute. Sc. Am. Sup. (No. 2206) Apr. 13, 1918.

Some Essentials to a Safe Diet. E. V. McColllum. Jo. Home Econ. 10:57-63. Feb. 1918.

Why Send Wheat? Lit. Dig. 57:3:29. Apr. 20, 1918.

The Whale as a Food Factor. C. H. Claudy. Sc. Am. 118:208-9. Mar. 9, 1918.

Food Exhibits and Lessons. Gen. Sci. Quar. 2:399-406. Mar. 1918.

FIRE AND EFFICIENCY

Reducing Fire Hazard (for motorists) T. W. Benson. Ev. Eng. Mag. 4:264. Mar. 1918.

FLIES

Effective Methods of Fly Control. Thomas J. Hedley. Sc. Am. Sup. (No. 2201) 85:150-151. Mar. 9, 1918.

FLOWERS

Flowers that Fertilize themselves. A. A. Hansen. Sc. Am. 118:406. May 4, 1918.

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# Index to Volumes I and II.

**Pages 1-248 are in Vol. I. Pages 249-484 are in Vol. II.**